

B1 cont
adjuvant. It is preferable that the mutant toxin is stable under the conditions where the toxin-containing vaccine is to be used. Further, mutants wherein the restoration of toxic activity is limited or negligible are preferable. "Restoration of toxin activity" refers to a phenomenon in which the toxic activity, which has been reduced greatly by a variety of treatments, is recovered as time progresses after the treatment. --

Please replace the paragraph at page 17, lines 14 to 22 with the following paragraph:

B2
--On the other hand, it is possible to choose amino acid residues or sugar residues to be mutated and to intentionally introduce a desired mutation in regard to the recombinant mutant toxin. Specifically, such alterations include one or more alterations of amino acid residue of oligopeptide moiety, sugar residue of oligosaccharide moiety, organic acid moiety, and such in the toxin molecule. The adjuvant of the invention also includes oligopeptide fragments such as peptide fragments playing an important role in the expression of immunopotentiating the activity of enhancing immunity. --

Please replace the paragraph at page 18, line 33 to page 19, line 8 with the following paragraph:

B3
--An artificial mutant toxin can be produced by an artificial mutant strain derived from toxin-producing wild-strain. The artificial mutant strain is generated from the wild-type-strain by the treatment with a mutagenizing agent, for example. Known methods of mutagenesis include, but are not limited to, chemical treatment, using chemical agents such as N-methyl-N'-nitro-N-nitrosoguanidine, nitrosourea, nitrogen mustard, etc., and physicochemical treatments, such as ultraviolet light irradiation, radiation exposure with cobalt-60 or the like, heating, etc. Culture of artificial mutant strains, purification of toxins from the mutant strains, and verification of the activity thereof are carried out essentially in the same manner as for the wild-type strains.--

Please replace the paragraph at page 21, lines 12 to 31 with the following paragraph:

B4
--The toxin is dissolved at an adequate concentration in a buffer. While the pH is adjusted to be within a range where the toxin is stable (typically, pH 5 to 8), an agent, for example, formalin, glutaraldehyde, phenol, iodine, acid anhydride, or a detergent such as bile

acid with the adequate concentration (typically, 0.01 to 1.0%) is added stepwise. Then the solution is incubated at an adequate temperature (for example, 5°C). After incubation, the agent is removed by any suitable method such as dialysis. The residual toxic activity is then assayed. If desired, the treated toxin is incubated again at a temperature at which the attenuated toxin will be used practically, for example, at 37°C, in order to confirm that the attenuated toxin does not revert to toxicity. The attenuated toxin of interest is thus yielded. This method is based upon the known method widely used for toxoid preparation, and is also suitable for large-scale production. However, it is preferable to use a method with which the toxic activity does not restore. There are some conventional methods used for this purpose. Exemplary methods include but are not limited to (1) the simultaneous addition of lysine in a quantity corresponding to the concentration of the agent for the attenuation treatment, for example, formalin, and (2) the performance of a reduction treatment \ after the attenuation.--

Please replace the paragraph at page 21, line 34 to page 22, line 12 with the following paragraph:

--The toxin is dissolved at an adequate concentration in a buffer. While the pH is adjusted to a pH at which toxic activity is generally lost, including an acidic pH (for example, pH 2 to 4) or alkaline pH (for example, pH 8 to 11), the solution is incubated at an adequate temperature. Alternatively, the solution is incubated at a temperature at which the toxic activity is generally lost (for example, at a temperature of 40°C or higher). Otherwise, the toxin is sonicated at an adequate wavelength, or irradiated with electromagnetic wave. The residual toxic activity of the sample is assayed before, during and after the treatment. If desired, the attenuated toxin is re-incubated at an adequate temperature, for example, at 37°C, confirm that the attenuated toxin does not revert to toxicity. If the activity of enhancing immunity is confirmed to be sufficiently high, then the preparation of attenuated toxin is completed. The chemical and physical treatments for attenuation can be properly combined--

Please replace the paragraph at page 22, lines 15 to 26 with the following paragraph:

--Residual toxic activity can be assayed by any conventional method (see, for example, "Handbook for vaccination," Ed. Research Association, National Institute of Health of Japan, Maruzen, 1994; "Protein toxin," 1st and 2nd volumes, Ed., R. Tamura et al.,

Bycont
Kodansha Scientific, 1972, etc.). The methods can be categorized as follows: enzyme activity assays, physiological-response assays using animal cells, physiological-response assays using animals, and evaluation methods utilizing survival and death of experimental animals, etc. The specific assay method to be used depends on the type of toxin. The following examples describe representative activities as marker for selecting such a method. Specific procedures for these assays are known. The comparison of toxic activity is not limited to these indexes, but as the matter of course the comparison of toxin activities before and after the attenuation should be carried out using the same index. --

Please replace the paragraph at page 33, line 28 to page 34, line 10 with the following paragraph:

B7
C2
--A cholera toxin-producing bacterium (*Vibrio cholera*; Inaba type 569B strain) was cultured in a semi-synthetic casamino acid medium (liquid medium containing glucose) designed by Finkelstein et al., at 30°C for 20 hours. After the culture was completed, the culture supernatant was subjected to ultrafiltration, using a filter having pores that the cholera toxin molecule (molecular weight; 86,000 Da) could freely go through. A small amount of aluminum hydroxide gel was added to the filtrate. The gel was allowed to adsorb the toxin and then was collected by centrifugation. The toxin was eluted from the gel with 10% phosphate-10% citrate (pH 7.6), while incubating at 30 to 35°C. The eluted liquid was dialyzed against an aqueous solution containing 0.1 M citrate. Then, the solution was loaded onto a column of DEAE-Sephadex and the toxin was eluted with phosphate buffer containing 0.1 to 0.2 M saline (hereafter abbreviated as PBS). Subsequently, the sample was loaded onto a column of Sephadex G-75 and the toxin was eluted with PBS. The resulting sample was subjected to gel electrophoresis. The presence of the cholera toxin as a single band. The purity was about 95%. The yield only was detected was 250 mg/100L culture broth. --

Please replace the paragraph at page 34, line 13 to 31 with the following paragraph:

B8
--The purified cholera toxin obtained in Example 1 was dissolved in 0.01 M PBS (pH 7-8). 0.05 M lysine was added to the solution. Then, to 6 aliquots of the solution formalin was added dropwise at final concentrations of 0.1, 0.3, 0.5, 0.6, 0.8, or 1.0%. The resulting solutions were incubated at 30 to 40°C for 7 to 96 days. Samples were withdrawn during the incubation. Immediately afterward, the collected samples were dialyzed against 20 times as

Ba
much volume of PBS to remove formalin. The dialyzed solution was then sterilized by filtration to give attenuated cholera toxin preparations. The time course of the activity change was investigated by using a part of the samples collected during the treatment. Figure 1 shows a typical time course where the sample collected on the twelfth day of the formalin treatment was assayed by the method for measuring the residual toxic activity, utilizing as a marker the ability to bind cholera toxin B subunit (a subunit having the binding activity to target cells of toxin; A subunit is responsible for the toxic activity) to ganglioside GM1, which is its receptor. The result shows that the binding ability of the attenuated toxin to ganglioside GM1 is reduced to about 1/15 and 1/100 of the natural one, when the toxin was treated with 0.3% and 0.5% formalin for 12 days, respectively.--

Please replace the paragraph at page 34, line 32 to page 35 line 9 with the following paragraph:

Ba
--The Y-1 cell morphological transformation test was utilized to assay the residual toxic activity of a variety of samples that were subjected to attenuation treatment under various conditions. Part of the result is indicated in Table 2. The result shows that the residual activity is reduced by a factor of about 1/1780 to about 1/114000 when the toxin was treated with 0.3% and 0.5% formalin for 12 to 96 days. Acute toxicity test was conducted in mice by using the attenuated cholera toxin prepared above. The attenuated cholera toxin, indicated in Table 2, in which the residual toxic activity was 1/7000 of the original activity or lower, did not show toxicity when administered intraperitoneally at a dose of 30 mg/kg. Accordingly, the toxic activity can be reduced to one-two thousandth or lower (using acute toxicity in mouse as marker) by treating the toxin with 0.3% formalin at 35°C for 12 days or more. --

Please replace the paragraph at page 35, lines 12 to 14 with the following paragraph:

Bio
--Residual toxic activity of formalin-treated cholera toxin (according to the result obtained by Y-1 cell morphological transformation test). --

Please replace the paragraph at page 35, line 18 to page 36, line 11 with the following paragraph:

bu
--HA antigen prepared from influenza virus PR8 strain (A/Puerto Rico/8/34, H1N1 type) that had been adapted to mouse was used as an antigen for the vaccine. Attenuated cholera toxin was used as the adjuvant. The residual toxic activity of attenuated cholera toxin used was 1/1780 to 1/114000 that of the original activity (according to Y-1 cell morphological transformation test). Five Balb/c mice (6-weeks-old, female) were used for each group in the test. The mice were anesthetized with sodium amobarbital, which was administered into the peritoneal cavity. 10 µl of PBS containing 1 µg vaccine antigen and 1 µg adjuvant was given dropwise to either nasal cavity of the mouse for intranasal immunization. Four weeks later, the secondary immunization was carried out in the same manner. Two weeks after the secondary immunization, sera and nasal washes were collected from the mice. --

Please replace the paragraph at page 36, line 12 to page 37, line 2 with the following paragraph:

bio
--The titer of anti-influenza virus antibody in the serum was determined based on the HI antibody titer. After bloodletting, the nasal washes were collected from the mice by perfusing the right and left nasal cavities with 1 ml of PBS containing 0.1% bovine serum albumin (BSA). The quantities of anti-HA-IgA antibody in the nasal washes and anti-HA-IgG antibody in the sera were determined by enzyme immunoassay (ELISA). Prior to the assay for anti-HA-IgA, each well of EIA plate was treated with 50 µl of HA vaccine (5 µg/ml) suspended in a coating buffer. The plate was allowed to stand for the coating at room temperature for 2 hours. The plate was then washed with PBS containing Tween-20 (hereinafter abbreviated as PBS-Tween). Subsequently, each well was coated with 100 µl of PBS containing 1% BSA and 0.1% NaN₃ to prevent non-specific reactions. The plate was allowed to stand at 4°C overnight, and then washed with PBS-Tween. A 100-µl aliquot of adequately diluted nasal washes sample was added to each well. After several hours, the reaction solution was discarded and the well was washed with PBS-Tween. Subsequently, 100 µl of alkaline phosphatase-labeled goat anti-mouse IgA α chain-specific antibody (or alkaline phosphatase-labeled goat anti-mouse IgG antibody) diluted with PBS containing 1% BSA and 0.1% NaN₃ was dispensed into the respective wells. The plate was allowed to stand at room temperature for an hour and then washed. Finally, p-nitrophenyl phosphate (1 mg/ml; Sigma Co.) dissolved in 10% diethanol amine buffer (pH 9.8) was added to each well

Big Con't
for color development. The plate was allowed to stand at room temperature for 20 to 30 minutes, and then the coloring reaction was monitored at O.D. (405 nm) in a plate reader.--

Please replace the paragraph at page 37, lines 3 to 12 with the following paragraph:

Biz
--Figure 2 shows the influence of an influenza vaccine, comprising attenuated cholera toxin prepared in Example 2 as the adjuvant, on the production of anti-influenza HA IgA antibody by the secondary response in the nasal washes. When the adjuvant-free vaccine was administered intranasally, the titer of anti-HA-IgA antibody was low. On the other hand, it was observed that the titer of anti-HA-IgA antibody in the nasal washes was markedly elevated in the group given primary and secondary vaccine containing attenuated cholera toxin. The titer of antibody is comparable to that of the control in which the same dose of natural cholera toxin was used. --

Please replace the paragraph at page 37, lines 13 to 20 with the following paragraph:

Bit
--Figure 3 shows the influence on the production of anti-HA IgG antibody in the serum in the above-described test. The attenuated toxin elevated approximately 15 times the titer of HA antibody in the serum as compared with that with the adjuvant-free vaccine. However, the antibody titer was about half of that with natural cholera toxin used as a control. These results show that the attenuated cholera toxin is useful as the adjuvant for vaccine, for example, when the local immunity is required to be enhanced. --

Please replace the paragraph at page 37, line 23 to page 38, line 6 with the following paragraph:

Sub C3
Bis
--A variety of attenuated cholera toxins, of which residual toxic activities were all less than one-two thousandth of that of the natural one, were used as the adjuvants. The same experiment as in Example 2 was repeated several times to assay the titer of anti-HA-IgA in the nasal washes and titer of IgG antibody in the blood of mice. The antibody titers determined in each assay were converted to relative values to those observed when the same amounts of natural cholera toxin were used as positive controls. The relative value is indicated as the ordinate axis and the attenuation rate of the toxin (relative residual activity to the natural one) was indicated as the abscissa axis (Figure 4). It is obvious that the majority of attenuated toxins, of which residual toxic activities are at least one-two thousandth that of the

B1504
C3

natural one (one-two thousandth $=4^{-5.46}$), exhibit high levels of antibody production-enhancing activity comparable to that of the same amount of natural cholera toxin. In particular, it was verified that the attenuated toxins, of which residual toxic activities are reduced to less than one-two thousandth that of the natural one, show comparable or higher efficacy as compared to that of original toxin on intranasal administration in regard to the enhancement of antigen-specific mucosal IgA formation.--

Please replace the paragraph at page 38, lines 9 to 22 with the following paragraph:

B14

--A cholera toxin attenuated by the formalin treatment (having a residual toxic activity of about 1/1048000 that of the natural one in Y-1 cell morphological transformation test) and *E. coli* heat-labile toxin B subunit (untreated), which toxic activity had previously been confirmed to be weak, were used as the adjuvant together. This experiment was carried out in the same manner as in Example 3. The cellular immune response to influenza virus was evaluated by the mouse foot pad. The result is shown in Figure 5. When 1 μ g of *E. coli* heat-labile toxin B subunit and 0.1 μ g or 0.01 μ g of attenuated cholera toxin were used together, the adjuvant enhanced immune response evidently much higher than that exhibited with the same amount of attenuated cholera toxin alone. The result shows that the dose of attenuated toxin can be further reduced by the method in which the attenuated toxin is used together with another adjuvant.--

Please replace the paragraph at page 38, line 26 to page 39, line 10 with the following paragraph:

B17

--Diphtheria toxin and pertussis toxin was prepared according to a method described by the Kitasato Institute for producing diphtheria vaccine and pertussis vaccine ("Textbook of techniques for vaccine production," Kitasato Institute, 1986). Each toxin was attenuated in the same manner as shown in Example 2 and was adsorbed on aluminum gel and used in the subsequent experiments. In addition, commercial Staphylococcal α toxin (Sigma Co.) and enteritis vibrio thermostable toxin (Sigma Co.) were purchased and attenuated in the same manner as described in Example 2. The toxins were used without further modification. A recombinant mutant LTR(7)K (lysine residue is substituted for arginine residue at amino acid position 7 from the N terminus) of *E. coli* heat-labile toxin was prepared by a method described by Komase et al. (K. Komase et al., Vaccine 16, 248-254, 1998). Thus five types

B1704
of attenuated toxins were obtained. The effect of enhancing immunity of influenza vaccine was tested according to the same method as described in Example 3, except that the attenuated toxins prepared above were used at appropriate concentrations instead of the attenuated cholera toxin in Example 3. The result is shown in Table 3, where relative value of residual toxic activity of attenuated toxin (ratio of toxin attenuated versus the natural one) is also indicated.--

Please replace the paragraph at page 39, lines 11 to 14 with the following paragraph:

sub
CIA
B18
~~--The result shows that both adjuvants of the invention, whether the natural toxin or the recombinant mutant toxin, exhibit activity of enhancing immunity of influenza vaccine administered by the intranasal route.--~~

Please replace the paragraph at page 41, lines 1 to 15 with the following paragraph:

B19
--Vaccine prepared as above containing pertussis-diphtheria-tetanus combined vaccine and attenuated toxin was inoculated to mice of each group. The same amount of the vaccine was further given to each mouse for supplementary inoculation after 4 weeks. After 2 weeks following the last immunization antibody production was evaluated. When vaccine alone was inoculated into mice, the titers (international unit) of anti-pertussis toxin antibody, anti-diphtheria toxin antibody, and anti-tetanus toxin antibody were 2.0 units or lower, 2.0 units or lower, and 1.5 units or lower, respectively. On the other hand, the other group subjected to vaccination with attenuated toxin showed respective titers of 88.6, 61.8, and 75.5 units. The test result indicates that, in the group subjected to vaccination with attenuated toxin, the amount of produced antibodies against the respective antigens are larger than those in mice inoculated with the adjuvant-free vaccines.--

Please replace the paragraph at page 42, lines 6 to 12 with the following paragraph:

B20
--A tetanus antibody assay kit "KAKETSUKEN" was used for assaying antibody titer in the blood. The assay result for the titer of antibody against tetanus toxin is shown in Table 4. After seven weeks, the antibody titer was found to be higher in the group given vaccine with attenuated cholera toxin than that observed in the group given vaccine without attenuated cholera toxin (control). --

Please replace the paragraph at page 43, lines 13 to 14 with the following paragraph:

B21
--Example 10 - Pharmaceutical preparation containing Japanese encephalitis vaccine and attenuated cholera toxin (injection):--

Please replace the paragraph at page 44, lines 16 to 25 with the following paragraph:

B22
--The antibody titer in mouse blood was assayed according to the same method as described in Example 11 except that the attenuated pertussis toxin (the same as prepared in Example 6; having a toxic activity of about 1/100000 that of the natural one when observed by CHO cell morphological transformation test) was used instead of the attenuated cholera toxin used in Example 11. The ELISA antibody titer was 0.19 for measles or 0.070 for rubella in mice subjected to the inoculation of the adjuvant-free vaccine, and the titer was 0.32 for measles or 0.16 for rubella with attenuated pertussis toxin-containing vaccine. --

Please replace the paragraph at page 44, line 27 to page 45, line 4 with the following paragraph:

--Example 13 - Pharmaceutical preparation containing rotavirus vaccine and attenuated recombinant E. coli heat-labile toxin (oral vaccine, and nasal drop):

B23
Rotavirus vaccine was mixed with a fraction containing attenuated recombinant LTR(7)K (having a toxic activity of about 1/260000 that of the natural one; the same as in Example 6) that had been dissolved in PBS and sterilized by filtration. 20 µl of the solution contained rotavirus vaccine, of which amount corresponded to 3.5 µg of virus particles, as well as 10 µg attenuated recombinant LTR(7)K. A preservative (0.01% thimerosal) as well as a stabilizer (0.2% porcine gelatin) was added to the solution. The solution was dispensed into appropriate containers, and was used as the oral inoculum or nasal drop of rotavirus vaccine-attenuated LT toxin. The preparation was stored at a temperature of less than 10°C in a cool and dark place. --

Please replace the paragraph at page 45, lines 21 to 24 with the following paragraph:

B24
--3. The adjuvant of the invention exhibits a comparable level of immuno-potentiating activity to that of the natural one at the same dosage, even when the residual toxic activity has been reduced to an undetectable level.--